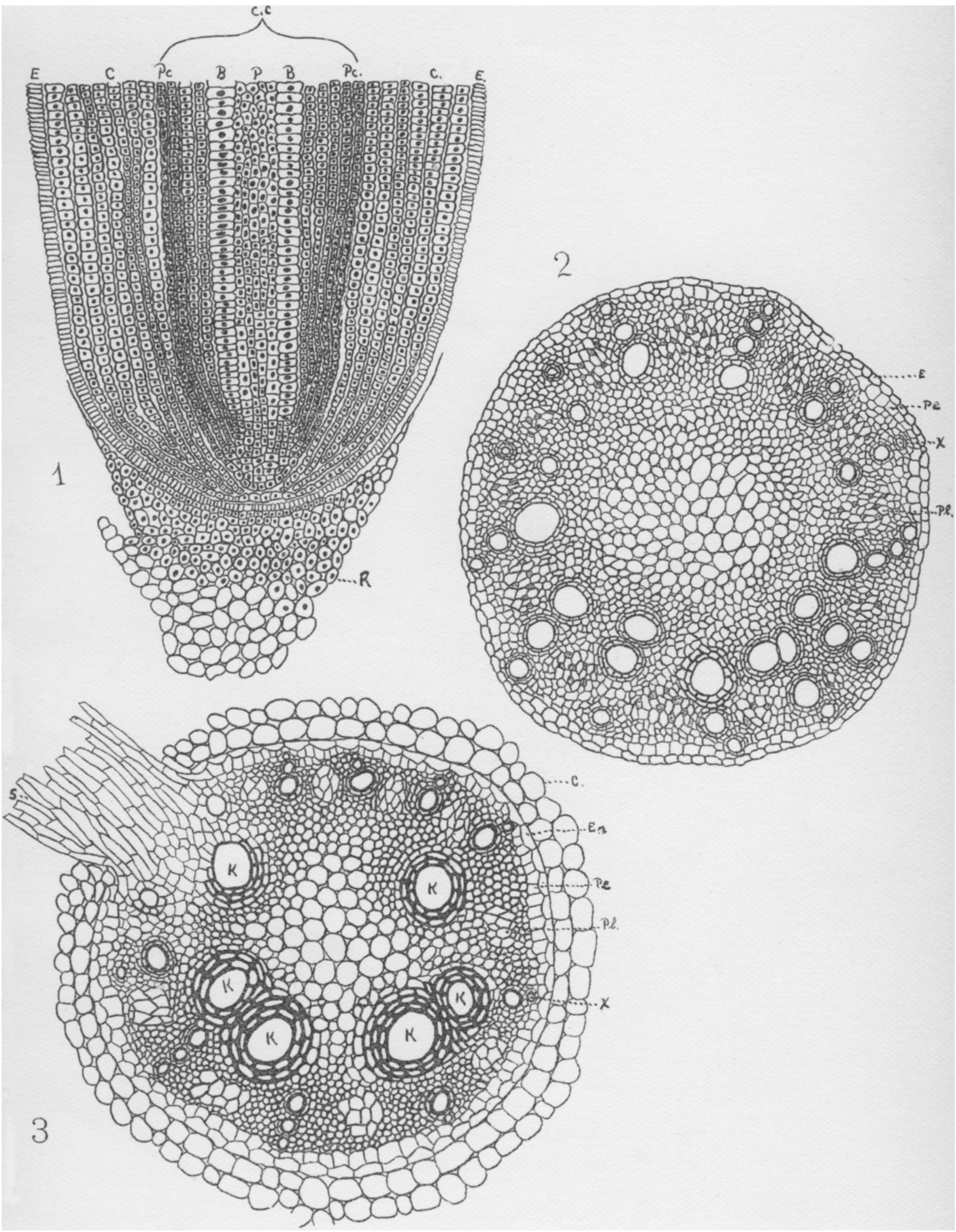

EMBRYO OF ZEA MAYS.

The Histology of the Embryo of Indian Corn.

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(PLATE 342.)

The general appearance of the kernel of Indian corn is familiar to every one. The embryo is literally at the base of the seed and, on the side adjacent to the endosperm, has a shield-like expansion of the hypocotyl—the scutellum—which has been interpreted usually as the cotyledon. There is a close coherence between the tissue of the scutellum and the tissue of the endosperm. On this account it is difficult to separate the embryo from the remainder of the seed without destroying some of its tissue. A well-marked layer of columnar epithelial cells, belonging to the scutellum, separates the embryo from the endosperm.

The axis of the embryo consists of the radicle, which is below the point of attachment of the axis to the scutellum, and the plumule, above the point of attachment. There is no obvious hypocotyl. The radicle is completely encased in the coleorhiza or root-sheath. Unlike many other grasses there is no epiblast present in the embryo of corn.

Calyptrogen. At the apex of the root is a distinct calyptrogen from which by periclinal walls the root-cap is formed (fig. 1). The many-layered root-cap, in its younger, more internal part, consists of parenchymatous tissue without intercellular spaces ; in the older, more external parts, it is loose and in many respects degenerated. The root-cap by its origin and development must be considered a modification of the epidermal tissue system.

Dermatogen. Immediately within the calyptrogen, occurs a single row of cells somewhat elongated radially and with a thick outer wall. This is the dermatogen (fig. 1), and is the formative tissue of the epidermis. In the course of development the layers resulting from divisions of the dermatogen exfoliate and the layer of the cortex, which functions as an epidermis, is designated an epiblem.

Periblem. This arises from a single layer, and indeed apparently

from an initial cell, at the apex of the root. In examining many sections, it was found that in no case did the dermatogen and periblem originate from a common initial cell. On the contrary, the initial cells of the two tissues appear quite distinct as do also the cells resulting from their divisions. This observation does not agree with that of Bowers (Prac. Bot.), who finds that "the periblem and dermatogen merge into a single layer of cells at the apex of the plerome. Thus the extra-stellar tissue of the root of maize comes primarily from a single initial row of cells."

Plerome. At the growing point the plerome consists of closely packed tissue. It soon differentiates into a peripheral region, the procambium, and a central region—the medulla. At a short distance from the apex of the plerome and well within the medulla appear rows of larger cells. Traced backward from the tip, these rows of cells are seen to increase in size much more rapidly than the surrounding tissue and simultaneous with their enlargement their nuclei break up and finally disappear altogether. After attaining full size and losing almost all their contents, their walls begin to show reticulated thickenings. Whether the agency in the thickening is the cell of the row or the cells abutting on the row, is not at present certainly known. Their appearance led at first to their being regarded as in no way related to vascular elements but the characteristic thickening points toward that relationship. They are very unique structures and so far as we can find they are confined to the grasses. Most species of grasses, if indeed not all, have them, some having only a single one in the center of the root while others, such as the species we are studying, has several of them.

The Root. For a study of the permanent structure of the root, cross-sections taken at some distance from the growing tip serve best. This shows the xylem and phloëm arranged radially (fig. 2). Strongly thickened and narrow-lumened cells make up the ground tissue which surrounds the xylem and phloëm strands. Every ray of xylem consists, in its outer part, of a group of very small elements, and, in its inner part, of very large and isolated ducts (pseudo-vessels). In each ray of phloëm the sieve tubes stand principally in a circle, the companion-cells occupying the inner part. The xylem and phloëm are separated laterally by sev-

eral rows of cells. The wide-lumened vessels toward the center are not in direct line with the outer xylem elements and stand quite isolated. They have somewhat thickened fibrous elements however, immediately around them. The medulla is made up of ordinary conjunctive tisssue.

The Stem. The bundles of the stem of corn present the well-known collateral type with the characteristic vessels, figures of which are given in most of the botanical text-books.

Transition of Bundles in passing from Root to Stem. The change from the collateral bundles of the stem to the radial bundles of the root, presents in this plant an interesting peculiarity. In tracing the course of the bundles from the root back to the stem it at once becomes apparent* that the radial type of bundle is maintained in the internode above the scutellum (fig. 3). The structure in the root and in this first internode is so similar that it is practically impossible to separate slides with cross-sections of the one, from slides with cross-sections of the other. The radial type is maintained throughout the whole length of the internode. In this respect our observations do not coincide with those of Potter (see Proc. Camb. Soc., **4**: 1883). He says "above the node," (node at which the bundles are given off to the scutellum) "we find the protoxylem the most internal part of a more or less continuous ring of xylem show that the rotation is complete." The only change in the internode that we could discover was a slight lateral expansion of the phloem strands. Sections cut directly on the other side of the second (sheath) node show true stem structure both as regards the position of the elements composing the bundles, and the distribution of the bundles through the mass of ground tissue.

Course of the Vascular Bundles in the Embryo. It will be most convenient to trace the bundles from the root backward into the stem and leaves. In the root we have the true radial arrangement of the xylem and phloëm strands. The outer edge of both strands abuts directly upon the endodermis. They maintain this position the entire length of the root. At the first node a branch is given

*This should properly be designated a false internode. The node at the insertion of the sheath appears from the description which follows to be the first true node, the scutellum node a false node.

off to the scutellum. When they emerge from this node into the first internode, they show very little change either in structure or relative position. The vessels of the xylem have moved slightly outward and the large inner elements have become smaller (fig. 3). The phloëm has spread slightly laterally. This latter change becomes more apparent as we approach the second node and is the first step in the transition from radial to collateral arrangement. In the second node the elements composing the bundles decrease. This decrease is accompanied by a bending of the bundle outward. The phoëm of the primary bundles then disappears and only a very few of the xylem elements are distinguishable. Before the disappearance of the phloëm of the root, the xylem of the leaf-trace bundles makes its appearance. These leaf-trace bundles arise, either internally or externally or laterally in close proximity to the root bundles. They pass toward the center of the stem, the xylem and phloëm elements of the bundle at once assuming the collateral position. The bundles of the sheath and the first leaf originate in the same manner.

Four collateral bundles segregate into two pairs at almost opposite points in the node, then pass out with a sharp curve into the sheath. This curve of the leaf-traces of the sheath is so sharp that in cross-section many of the xylem elements are cut lengthwise. The leaf-trace bundles of the first leaf pass inward to near the center of the stem and upward through the second internode. After traversing about one-half the length of the second internode they commence to curve outward and at the third node pass out into their leaf. In the cross-section of this node a new set of bundles much smaller than those just considered, and about equal in number to them, make their appearance. They are the bundles which pass into the leaves above. The course of the bundles in the succeeding nodes and internodes corresponds to the type of bundle distribution found in palms and other monocotyledons.

In conclusion: 1. The bundles of the primary root of Indian corn are of the true radial type. 2. The innermost elements of the xylem are anomalous and doubtfully to be considered as true ducts. These anomalous elements occur in many species of grasses but have not been met with in other orders. 3. The leaf-trace bundles of the scutellum do not in any way affect the ar-

rangement of the main bundles, and in this respect rather resemble the bundles given off to the secondary roots. 4. The first internode closely resembles the root in structure. The peculiar arrangement of the bundles may be in some way related to the failure of the first internode to attain a diameter greater than that of the primary root. 5. The fibro-vascular bundles change from the radial type to the collateral type in the second node. These bundles on entering the second node pass outward and terminate blindly toward the periphery, the last elements to disappear being the xylem elements. 6. The bundles of the sheath differ from those of normal leaves in that they originate in the node from which they are given off, that they blend into pairs and finally in the sheath appear as two bundles at opposite points on the axis, and that the curves of this bundle in the node are very sharp.

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Explanation of Plate 342.

1. Longitudinal section of root-tip. 2. Cross-section of root. 3. Cross-section of first internode. Ep. Epidermis. C. Cortex. Pc. Procambium. B. Pseudo-vessels. C.C. Plerome. R. Root-cap. En. Endodermis. Pe. Pericycle. Xy. Xylem. S. Secondary root. K. Large vessels. Pl. Phloëm.